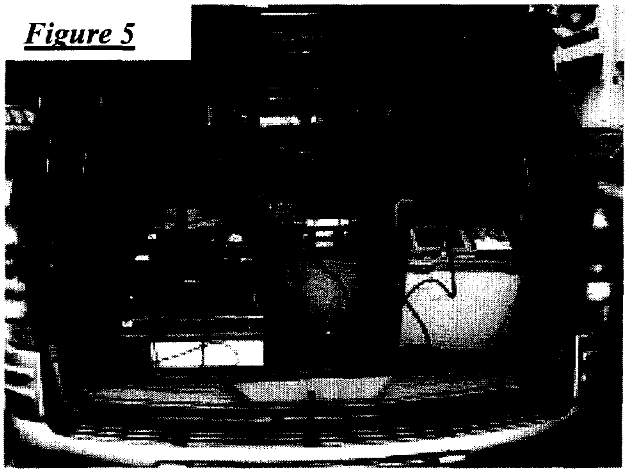
Figure 5

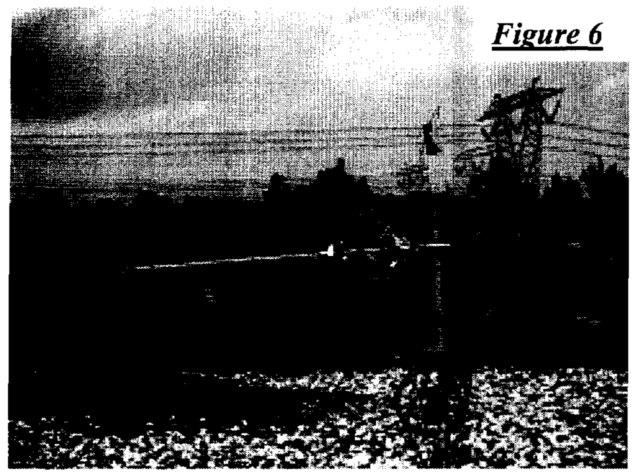


In most outdoor sites, the equipment, mounted on portable luggage carriers, was physically located in the mobile van (*Figure 5). The antennas, mounted atop the same 5-foot tripod, were placed in a variety of receiving locations. From these locations the same receivability factors for both 8VSB and COFDM were gathered as noted above.

For the far field outdoor sites, a Yagi antenna (*Figure 6) replaced the simple antennas. In the far field tests the objective was to receive the transmitted signal and assess the margin to loss of picture. The purpose of the tests at these sites was to determine if differences were measurable using the two different modulation technologies. As mentioned earlier, by placing an adequate gain LNA at the front of the test system allows the differing receiving noise figures to be normalized (Figure 3).

4.) Test Results

Figure 6



The system was put "on-line" in the middle of June, with test results gathered between June 21 – August 4, 1999. For the purposes of this document, the term "Near-Field" roughly correlates with Grade A and City Grade coverage areas, while "Far-Field" represents the Grade B and beyond.

Data Summary

Raw data is detailed in the data summary section [9]. For informative purposes, some of the data has been used to generate charts where the information can provide a more graphic "picture" of the data. Out of some of the charts it is quite simple to "see" some major distinguishing features of the two (2) systems under test. Multiple charts have been generated from the sites where complete data was gathered. It should be noted that while 40 sites were completely documented, a number of additional sites were investigated. The anecdotal results from these additional sites, while not included in the charts and data, were consistent with the results indicated in the charts.

[9] Addendum B, Data

Indoor Reception

These charts show the number of fully documented "Near-field" test sites (31) versus reception (8VSB and COFDM) with different antenna types.

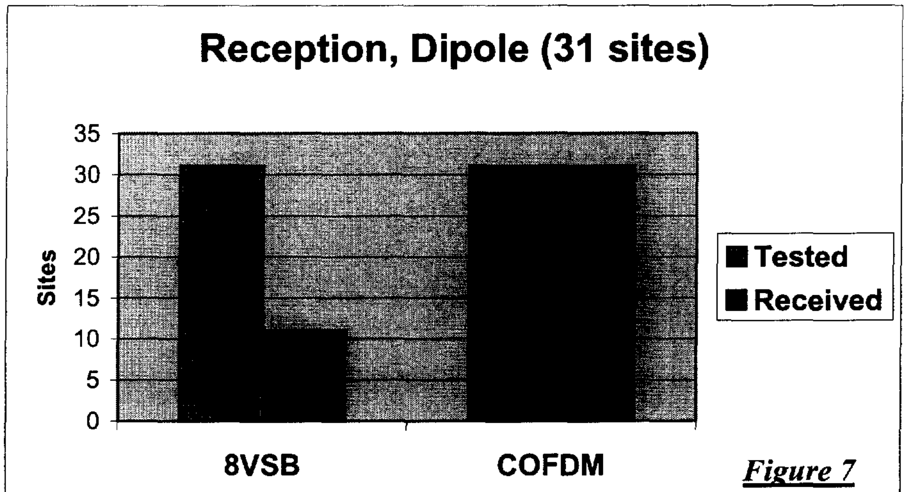


Figure 7

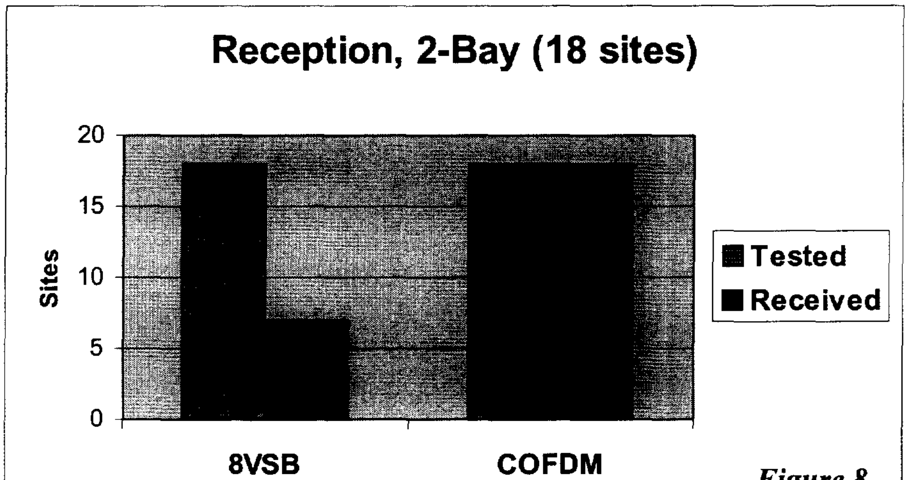


Figure 8

"Ease of Reception" (Reception versus Antenna Orientation)

These charts plot the orientation of the receiving antenna as an area function, distributed across the indicated number of receiving opportunities. It is easy to see the area of service that the two systems offer across the total of the tested sites. The less sensitive to antenna orientation the more likely no adjustment will be required upon a channel change. Thus, a higher degree of reception ease.

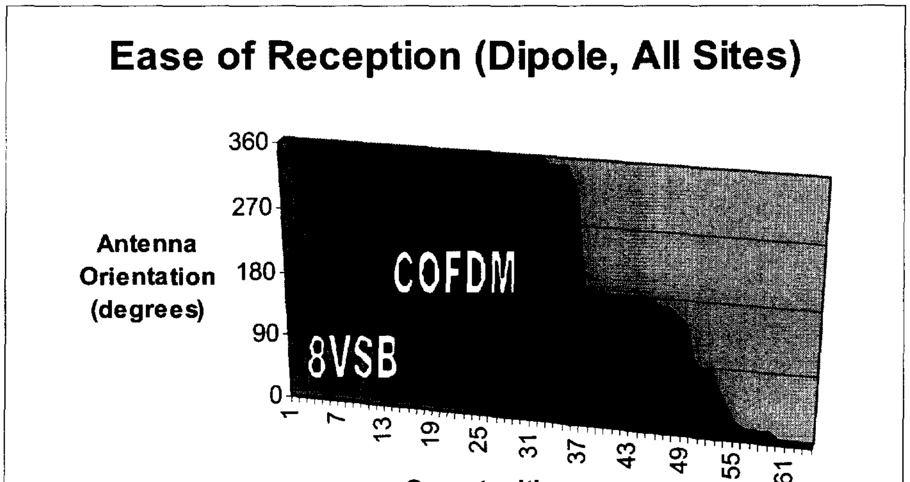


Figure 9

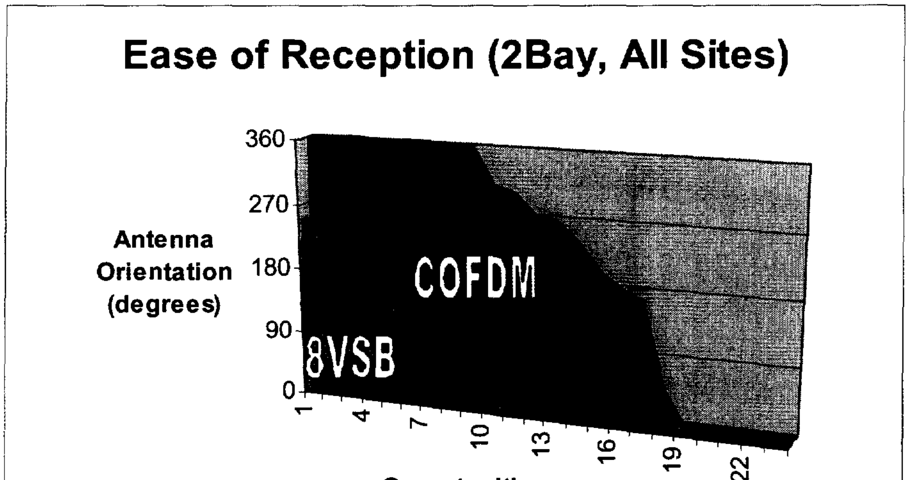


Figure 10

Reception versus Spectrum "flatness"

After analysis of the many spectrum plots[10] gathered during the course of this test, it is possible to make several "global" statements regarding the relationship between spectrum shape and receivability for the generation of receivers tested.

Almost three quarters of the fully documented sites were located in the "Near-Field". In particular, sites recorded within a ten (10) mile radius of the transmitting antenna have a variety of spectrum shapes, influenced by the wide variety of multi-path sources. This is typical of that expected in a city or at an indoor location. Looking at the spectrum plots [11] one can easily imagine a make-up of highly complex near and far dynamic reflections.

What cannot be gathered from these plots, but is noted in the data summary sheets, is the moving nature of the multi-path in many of these environments. This movement may be slow (close by pedestrian), or fast (influenced by traffic, airplanes, etc.) and it certainly influences reception in many locations.

First, in no location, under any conditions, was it possible to receive 8VSB with spectrum deviations in excess of ~15dB. (*Figure 12) On the other hand, examples can be shown of COFDM threshold of failure at ~25dB (*Figure 14) with major spectrum deviations.

Secondly, 8VSB was sensitive to the location and periodic nature of spectrum nulls. These spectrum distortions which are the result of all types of multi-path propagation, occurring at the same time at the same location which places an enormous burden on the 8VSB adaptive equalizer. This complex ensemble of dynamic multi-path conditions far exceeds the expectations that were the basis of the current generation of adaptive equalizer designs. This was NOT the case with COFDM, where under identical multi-path impairments, reception was possible in all documented locations.

8VSB was quite intolerant of dynamic multi-path. COFDM exhibited the ability to track most changing multi-path conditions.

[10] Addendum
[11] Figures 11 - 14, Spectrum plots

EXAMPLES

Example 8VSB "Nominal Reception"

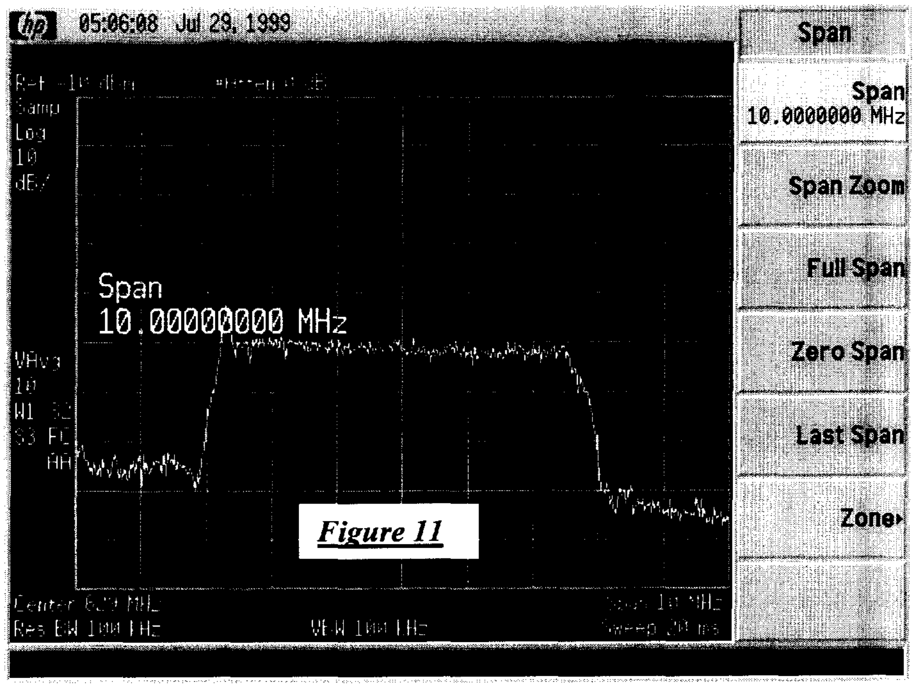


Figure 11

Example 8VSB "Threshold of Failure" (note <15 dB null)

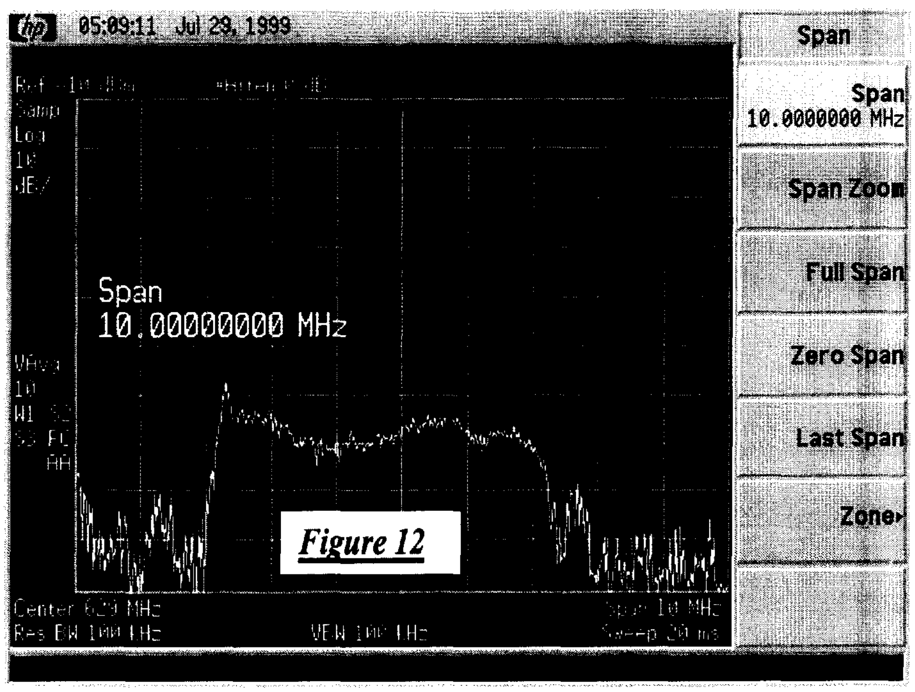


Figure 12

EXAMPLES

Example COFDM "Nominal Reception"

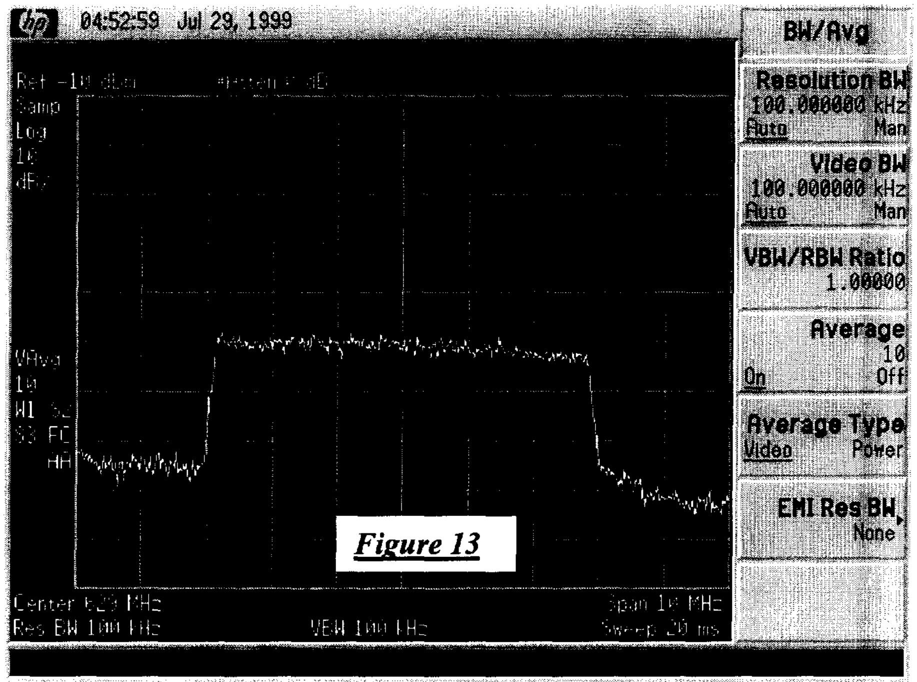


Figure 13

Example COFDM "Threshold of Failure" (nulls >25dB, at noise threshold)

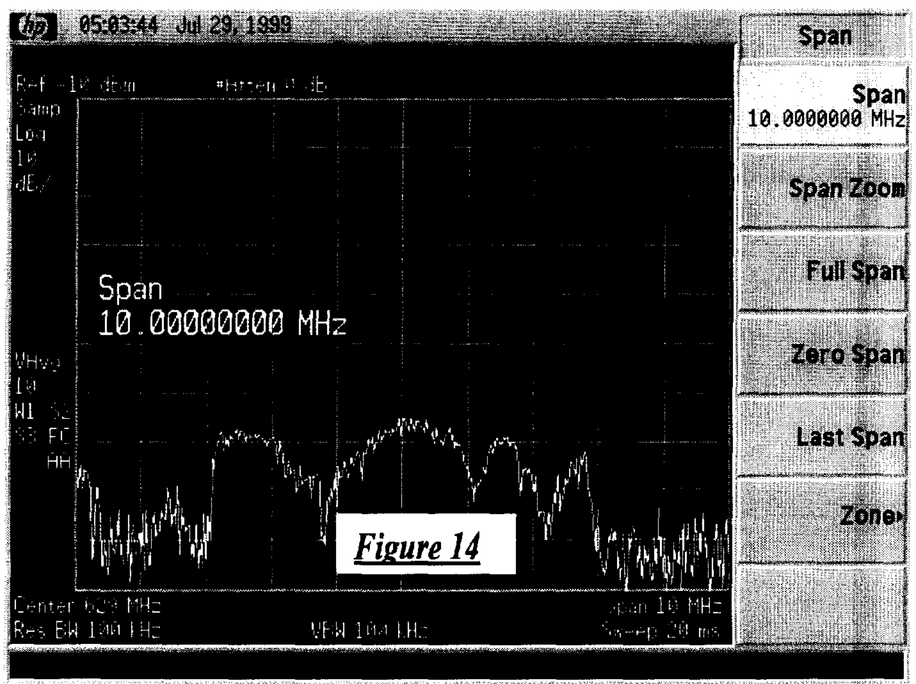


Figure 14

Receiver Margins

The following charts indicate the ability to successfully receive and decode the DTV signal, and the associated "margin to failure" exhibited by individual units at 31 sites, indoor and outdoor, within the "near field" (less than 30 miles). The colored area of the graphs represent the margin available at the receiving locations.

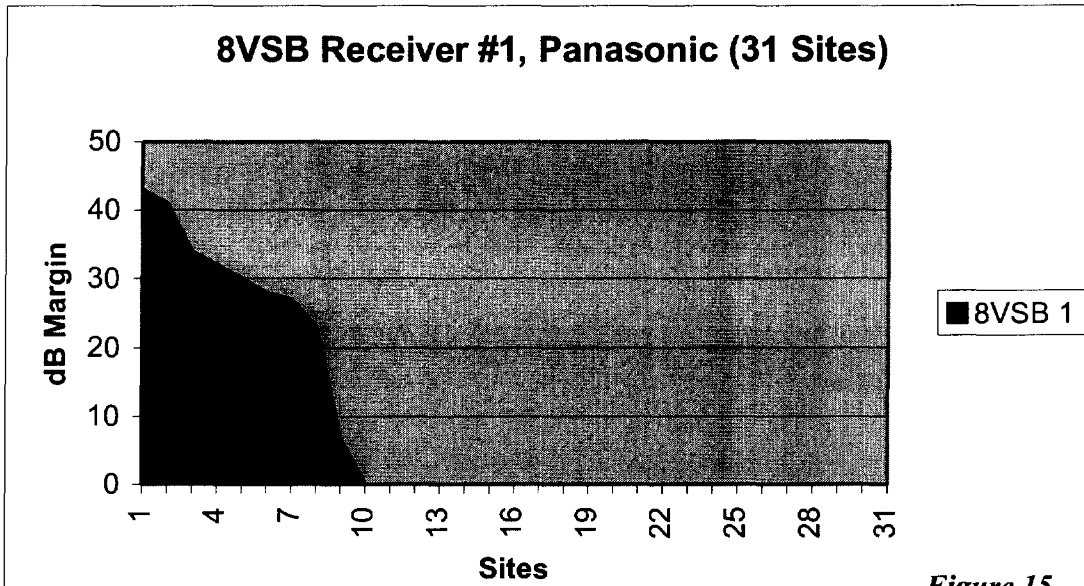


Figure 15

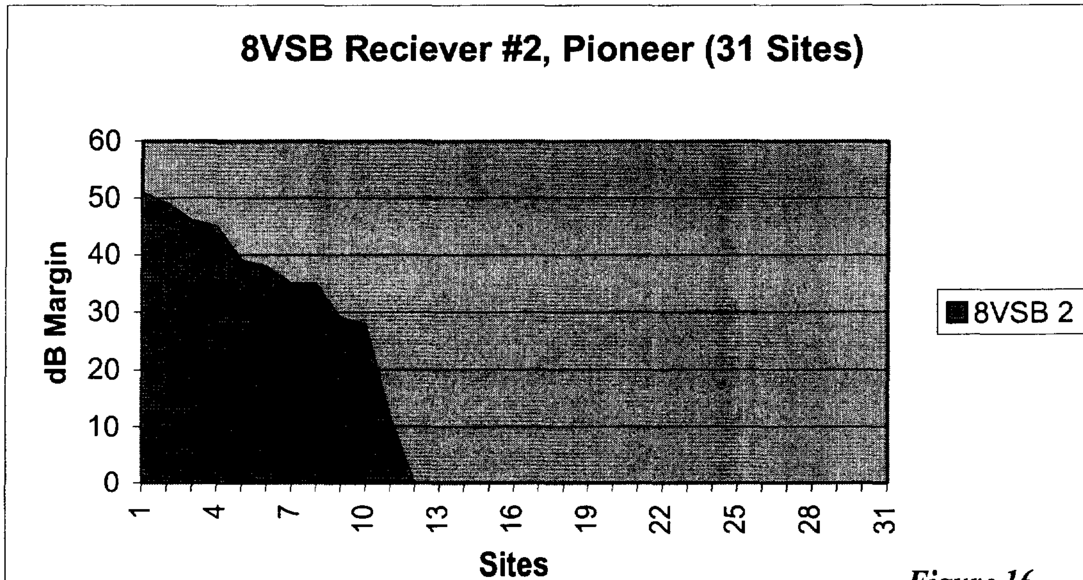


Figure 16

Receiver Margins

It is easy to see that COFDM was received in a much larger number of sites (all sites for the Nokia COFDM receiver). Additionally, the older receiver technology of the NDS COFDM unit out performed the current generation 8VSB product by a large margin.

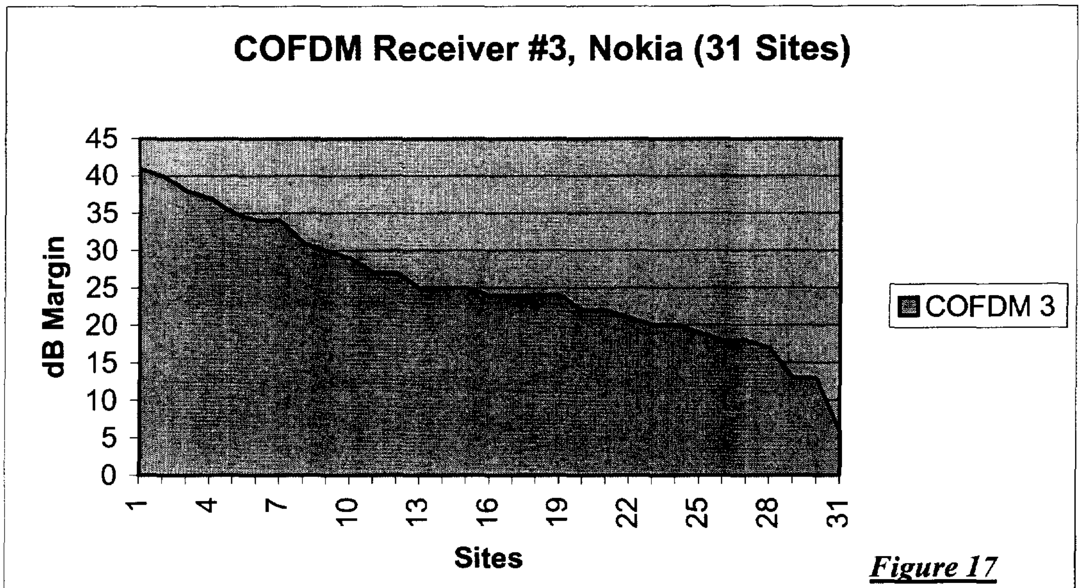


Figure 17

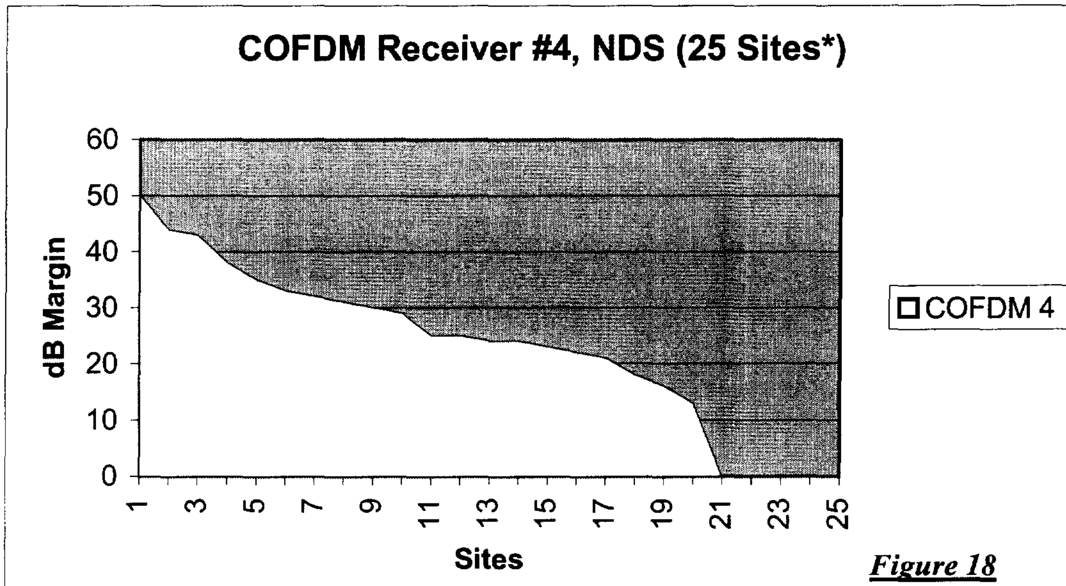


Figure 18

** The NDS unit developed a failure and was not used at 6 sites.*

Far Field Data

The purpose of the "Far-field" testing was to try and determine if a meaningful difference in performance could be observed. Some of the data collected indicates that, even though a C/N difference exists in the theorectical performance of the two systems (~15dB for 8VSB & ~19dB for COFDM), real world data conditions did not allow a demonstration of this difference. By using the Low Noise Amplfier (LNA) (~2.7dB noise figure) at the front of the receiving system to set the noise factor for reception, the difference in site margins, on the average, shrink to within 2.0dB (see charts below). The average daily calibration threshold difference between 8VSB and COFDM was measured (on the same day of data) at 3.28 dB (81.71 – 78.43). However, in the field, the average difference shrank to within 2.0dB (82.57 – 80.57) [12]. The difference between this field data and the daily calibration data done at the transmitter, may be attributed to the effect of real world path impairments that add to the "gaussian" channel.

8VSB				COFDM			
Rcvr. Level	**Site Margin**	***CFT**	**Daily Cal. Sum**	**Rcvr. Level**	**Site Margin**	***CFT**	**Daily Cal. Sum**
-54	29	-83	81	-54	25	-79	79
-43	41	-84	82	-42	38	-80	78
-63	18	-81	81	-62	20	-82	79
-47	36	-83	82	-47	34	-81	78
-35	47	-82	82	-35	45	-80	78
-42	41	-83	82	-42	40	-82	78
-53	29	-82	82	-54	26	-80	79
*Calculated	SUM	-578	572	*Calculated	SUM	-564	549
Field Threshold	**AVG.**	**-82.57**	81.71	Field Threshold	**AVG.**	**-80.57**	78.43

Chart 2

Analysis of Sites

During the test program, several chip and receiver manufacturers ran their own tests. While all but one of these manufacturers have requested that their data be held in confidence, the Oak Report [13] provides a great deal of insight regarding some of the specifics of the multi-path at several of the sights contained within this report. Based on the open nature of this published report, several other chip manufactures have stated that attempts have been made to enable new generation devices work within the environments typified. The missing component from such simulations has been an ability to replicate the dynamic nature of these environments.

---

[12] See Chart 2

[13] Addendum C, Oak Technology "Baltimore Report"

5.) Summary, Comments and Conclusions

Sinclair Broadcast Group underwrote this test effort because they believed that the very essential need to have DTV be an easily received service by the public was being over looked by the advocates of the proposed system. Early independent testing by Sinclair raised concerns that needed to be addressed. One claim that was put forward was that 8VSB was the only system that could deliver a data rate suitable for HDTV in a 6 MHz bandwidth. Another was that if COFDM was operated at HDTV data rates in 6 MHz it would be just as fragile as 8VSB and that indoor and portable reception with simple antennas was not an important consideration for broadcasters. The purpose of the Baltimore tests was to explore these claims and determine if 8VSB really was the best that could be achieved.

The authors recognize that the receivers used in the test are claimed to be first generation units. As such, certain defects in performance are supposed to be overlooked, despite the fact that they were being offered to the public as full HDTV capable receivers.

The data rate of the chosen COFDM parameters in 6Mhz allowed 18.67Mb/s. While ~3% below the data rate of 8VSB, it is still well above the generally held threshold for HDTV transmission at 18Mb/s. Furthermore, the reception of COFDM on a two year old receiver design far outperformed 8VSB receivers manufactured in early 1999, barely 3 months before the test began.

The need for indoor reception was ignored during the design phase of the 8VSB system. It was just too difficult at the time to define that environment. However, broadcasters today recognize that the cable industry may not be required to carry our signals and as such it is now essential that consumers enjoy easy reception with simple antennas which don't require adjustment. Providing service to portable devices using small antennas has now become more important than was originally anticipated. Portability and mobility were not a requirement during the design phase of the ATSC system that were given any level of priority. These requirements cannot be overlooked today and were thus part of the justification for mounting these tests.

Sinclair's tests also explored the importance of the C/N ratio difference between the two systems. By normalizing all test receivers to the same noise figure, in the far field, it was possible to establish a real world path difference between the systems. On the average this was a C/N difference of 2.0dB. While this seemed to show that 8VSB was more capable of providing service at the fringes of coverage, it became clear that such a difference is not material in a real world environment. This conclusion is drawn from the fact that while at the many sites investigated, both in detail and by anecdotal experience, no location in the "Far-field" could be found where 8VSB was received and COFDM was not received. On the contrary, 8VSB failed consistently at any site where complex multi-path existed while COFDM provided reliable service even at the fringes of coverage. It may be surmised from these results that the 2db real world C/N advantage for 8VSB, in this generation of receivers, is swamped by other path impairments that render the two system equivalent at the fringes. While it has been shown that 8VSB is operating near its theoretical limits [14] in terms of C/N, the generation of COFDM receivers used in this test are still 2 to 4 dB [15] away from their system limits of performance. This has come from many recognized authorities, including the latest BBC test reports on the current generation of COFDM chips. In short, COFDM can be expected to improve on these results with respect to C/N while 8VSB is just about at its limit.

It appears the results of the Baltimore tests demonstrate that the present generation of 8VSB receivers being offered to the public fall far short of the performance necessary to make DTV a success as an over the air service. The designers of these receivers clearly underestimated the complexity of the multi-path environment. As a result, the public has been presented with a very poor image of what "over-the-air" DTV can deliver. The broadcast community needs to decide if it is prepared to give up a viable and ubiquitous "over-the-air" delivery system in the name of expediting the roll out of DTV. If we are not prepared to rely on wired or satellite delivery of our signals and we are not prepared to give up the possibilities of providing digital broadcast services to portable receivers then we must demand better performance from 8VSB receivers or look elsewhere for our DTV transmission system.

This test was not performed to promote one system over another. It was undertaken to show that a benchmark of reception performance has already been achieved. This is a benchmark that we should demand be achieved by any transmission system we will have to live with for many decades to come.

[14] FACTS Summary Report for the Australian Field Trials of DVB-T and ATSC DTTB systems conducted in 1997, dated July 25, 1998

[15] Addendum D, Results of RF measurements with DVB-T chip-set and comparison with ATSC performance, A.P. Robinson and C.R. Nokes, BBC Research & Development dated 5/28/99

Acknowledgements

The authors wish to thank the many individuals and organizations which made this testing possible. A great deal of support was provided by the staff of WBFF-TV45, and their efforts did not go unnoticed. Providers of support and equipment include:

Sinclair personel including Dave Hackney, Ray Kiesel, Harvey Arnold, Andy Whiteside and countless others.

Acrodyne
Adherent
Andrew/PPP
Bird
Dielectric
DVB
Gramophone (Timonium)
K-Tech
NDS
Nokia
US Tower Systems

APPENDIX A

Site Measurements & Notes

Location:______________________________ PIC (Y) (N) __________

LAT : ________________ LON : ____________________

Specific Antenna Placement: ____

Weather: ____

8-VSB – Bow Tie Dipole

Channel Power Reference @ 3MHz RBW: _______________ (dBm)

Standard Spectrum Plot #: ____________________

Reception: RCVR #1: (yes) (no) (???) Margin: _______________ (dB)

RCVR #2: (yes) (no) (???) Margin: _______________ (dB)

Antenna Susceptibility to Change – Orientation RCVR #1

CCW___________° CW___________° FAIL / NO FAIL

Margin: _______ (dB) FAIL point or Worst case if NO FAIL Plot#:__________

NOTES: ____

Antenna Susceptibility to Change – Orientation **RCVR #2**

CCW___________° CW___________° FAIL / NO FAIL

Margin: _______ (dB) FAIL point or Worst case if NO FAIL Plot#:__________

NOTES: ____

Impulse Noise Test Note: ____

____

Dynamic Multipath Note:____

COFDM– **Bow Tie Dipole**

Channel Power Reference @ 3MHz RBW: ________________ (dBm)

Standard Spectrum Plot #: ______________________

Reception: RCVR #3: (yes) (no) (???) Margin: ________________ (dB)

RCVR #4: (yes) (no) (???) Margin: ________________ (dB)

Antenna Susceptibility to Change – Orientation RCVR #3

CCW____________° CW_____________° FAIL / NO FAIL

Margin: _______ (dB) FAIL point or Worst case if NO FAIL Plot#:____________

NOTES: ____

Antenna Susceptibility to Change – Orientation RCVR #4

CCW____________° CW_____________° FAIL / NO FAIL

Margin: _______ (dB) FAIL point or Worst case if NO FAIL Plot#:____________

NOTES: ____

Impulse Noise Test Note: ____

____

Dynamic Multipath Note:____

Site Measurements & Notes

8-VSB – Double Bow Tie Reflector

Channel Power Reference @ 3MHz RBW: ________________ (dBm)

Standard Spectrum Plot #: ________________

Reception: RCVR #1: (yes) (no) (???) Margin: ________________ (dB)

RCVR #2: (yes) (no) (???) Margin: ________________ (dB)

Antenna Susceptibility to Change – Orientation RCVR #1

CCW____________° CW____________° FAIL / NO FAIL

Margin: ________ (dB) FAIL point or Worst case if NO FAIL Plot#:____________

NOTES: ____

Antenna Susceptibility to Change – Orientation **RCVR #2**

CCW____________° CW____________° FAIL / NO FAIL

Margin: ________ (dB) FAIL point or Worst case if NO FAIL Plot#:____________

NOTES: ____

Impulse Noise Test Note: ____

____

Dynamic Multipath Note:____

COFDM– **Double Bow Tie Reflector**

Channel Power Reference @ 3MHz RBW: ________________ (dBm)

Standard Spectrum Plot #: ____________________

Reception: RCVR #3: (yes) (no) (???) Margin: ________________ (dB)

RCVR #4: (yes) (no) (???) Margin: ________________ (dB)

Antenna Susceptibility to Change – Orientation RCVR #3

CCW__________° CW__________° FAIL / NO FAIL

Margin: ______ (dB) FAIL point or Worst case if NO FAIL Plot#:__________

NOTES: ____

Antenna Susceptibility to Change – Orientation RCVR #4

CCW__________° CW__________° FAIL / NO FAIL

Margin: ______ (dB) FAIL point or Worst case if NO FAIL Plot#:__________

NOTES: ____

Impulse Noise Test Note: ____________________________________

____

Dynamic Multipath Note:____________________________________

Receiving Equipment

ATSC	RCVR#1:	Panasonic TU-DST50
ATSC	RCVR#2:	Pioneer Elite SH-D500
DVB-T	RCVR#3:	Nokia View Master Model 9600
DVB-T	RCVR#4:	NDS System 3000 Professional Terrestrial Receiver

<u>DTV Measurement Procedure</u>

Procedure at Transmitter Site – start and end of each test day

1. Confirm and record **<u>8-VSB</u>** transmitter power using spectrum analyzer, thermoelectric power meter and transmitter front panel (REL) meter.
2. Measure and record pilot frequency (8-VSB).
3. Measure and record shoulder performance (8-VSB) and SNR (EVM).

4. Confirm and record **<u>COFDM</u>** transmitter power using spectrum analyzer, thermoelectric power meter and transmitter front panel (REL) meter.
5. Measure and record power band center frequency (COFDM).
6. Measure and record shoulder performance (COFDM).

7. Record **<u>8-VSB</u>** Spectrum Analyzer Reference power at van.
8. Using sample of signal through receiver input components (pre-amp, cables, switches, splitter and attenuators), measure and record "fail point" level of Panasonic (#1) and Pioneer (#2) receivers.
9. Establish whether performance matches past performance.

10. Record **<u>COFDM</u>** Spectrum Analyzer Reference power at van.
11. Using sample of signal through receiver input components (pre-amp, cables, switches, splitter and attenuators), measure and record "fail point" level of Nokia (#3) and NDS (#4) receivers.
12. Establish whether performance matches past performance.

DTV Measurement Procedure (continued) Page 2

Test Location Procedure

1. Determine and record (GPS coordinates) location of site and antenna position at site (tripod).

2. Provide **8-VSB** signal from transmitter.
3. Use spectrum analyzer (3 MHz RBW) to optimize 8-VSB signal level using **bow tie dipole**.
4. Measure and record signal power level (8-VSB) at optimized position (above).
5. Obtain standard spectrum plot at maximum signal level (above).
6. Confirm performance on Panasonic (#1) and Pioneer (#2) receivers (8-VSB). Measure and record margin for each receiver (step attenuator).
7. Change antenna (dipole) orientation and note reception susceptibility to change. Record position change (in degrees) relative to signal quality, and note loss of reception if applicable. If failure occurs, record spectrum at failure point.
8. Determine and record plot of maximum signal degradation and make note of margin to failure (if applicable).
9. Turn on impulse noise generator (vacuum cleaner) to test for susceptibility to impulse noise. Note results.
10. Note susceptibility of reception to "local" dynamic multi-path (people movement, doors, vehicles, etc.).

11. Change transmitter to **COFDM**.
12. Use spectrum analyzer (3 MHz RBW) to optimize COFDM signal level using **bow tie dipole**.
13. Measure and record signal power level (COFDM) at optimized position (above).
14. Obtain standard spectrum plot at maximum signal level (above).
15. Confirm performance on NOKIA (#3) and NDS (#4) receivers (COFDM). Measure and record margin for each receiver (step attenuator).
16. Change antenna (dipole) orientation and note reception susceptibility to change. Record position change (in degrees) relative to signal quality, and note loss of reception if applicable. If failure occurs, record spectrum at failure point.
17. Determine and record plot of maximum signal degradation and make note of margin to failure (if applicable).
18. Turn on impulse noise generator (vacuum cleaner) to test for susceptibility to impulse noise. Note results.
19. Note susceptibility of reception to "local" dynamic multi-path (people movement, doors, vehicles, etc.).

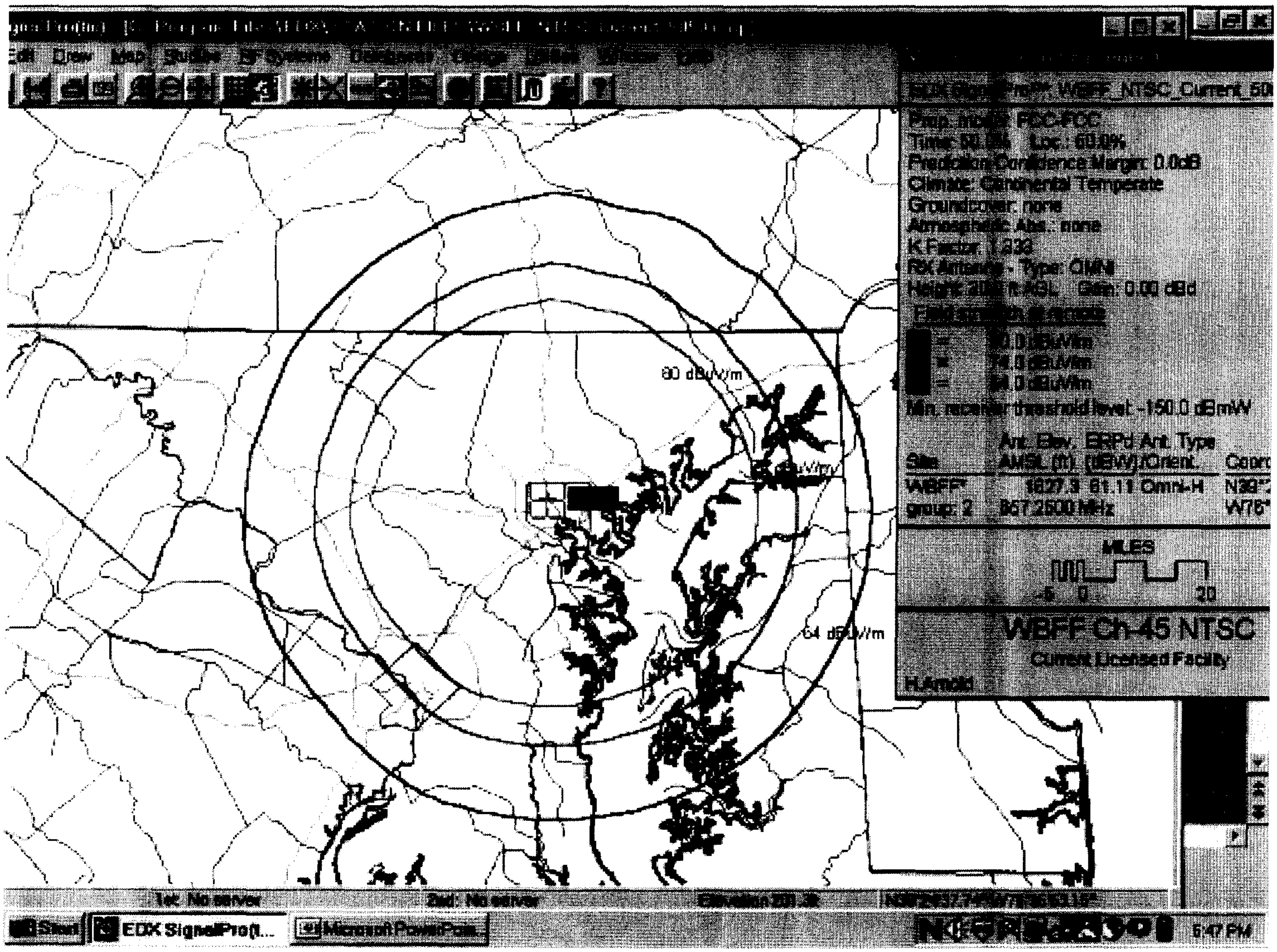
DTV Measurement Procedure (continued) Page 3

20. Change transmitter to **8-VSB**.
21. Use spectrum analyzer (3 MHz RBW) to optimize 8-VSB signal level using **double bow tie reflector**.
22. Measure and record signal power level (8-VSB) at optimized position (above).
23. Obtain standard spectrum plot at maximum signal level (above).
24. Confirm performance on Panasonic (#1) and Pioneer (#2) receivers (8-VSB). Measure and record margin for each receiver (step attenuator).
25. Change antenna (double bow tie reflector) orientation and note reception susceptibility to change. Record position change (in degrees) relative to signal quality, and note loss of reception if applicable. If failure occurs, record spectrum at failure point.
26. Determine and record plot of maximum signal degradation and make note of margin to failure (if applicable).
27. Turn on impulse noise generator (vacuum cleaner) to test for susceptibility to impulse noise. Note results. Note susceptibility of reception to "local" dynamic multi-path (people movement, doors, vehicles, etc.).

28. Change transmitter to **COFDM**.
29. Use spectrum analyzer (3 MHz RBW) to optimize COFDM signal level **double bow tie reflector**.
30. Measure and record signal power level (COFDM) at optimized position (above).
31. Obtain standard spectrum plot at maximum signal level (above).
32. Confirm performance on NOKIA (#3) and NDS (#4) receivers (COFDM). Measure and record margin for each receiver (step attenuator).
33. Change antenna (double bow tie reflector) orientation and note reception susceptibility to change. Record position change (in degrees) relative to signal quality, and note loss of reception if applicable. If failure occurs, record spectrum at failure point.
34. Determine and record plot of maximum signal degradation and make note of margin to failure (if applicable).
35. Turn on impulse noise generator (vacuum cleaner) to test for susceptibility to impulse noise. Note results. Note susceptibility of reception to "local" dynamic multi-path (people movement, doors, vehicles, etc.).

36. END

APPENDIX B



Prop. model: FCC-FCC
Prediction Confidence Margin: 0.0dB
Climate: Continental Temperate
Groundcover: none
Atmospheric Abs.: none
Min. receiver threshold level: -150.0 dBmW
Ant. Elev. ERPd Ant. Type
Site AMSL (ft) (dBW) /Orient.
WBFF* 1627.3 61.11 Omni-H
MILES
-5 0 20
WBFF Ch-45 NTSC
Current Licensed Facility
H.Arnold
80 dBuV/m
64 dBuV/m
1st: No server
2nd: No server
EDX SignalPro(t...
5:47 PM

APPENDIX C

Baltimore 8-VSB/COFDM Test Equipment List

Transmission Facility

Manufacturer	Model	Product
Adherent	SV953	MPEG Streamer
Andrew	HJ-8	Heliax
Comark	IOT "S-Series"	High Power Amplifier
Dielectric	TUP-2P-C1	Panel Antenna
K Tech	TSS-100A	MPEG Streamer
Passive Power Products	CIF	DTV Mask Filter
Passive Power Products	LPF	Harmonic Filter
Rhode & Schwarz	SFQ	TV Test Transmitter
Rhode & Schwarz	SD100D	TV Exciter
Rhode & Schwarz	DVG	MPEG-2 Generator
Zenith	DTV MOD	ATSC/DTV Modulator

Test Equipment

Maufacturer	Model	Product
Hewlett Packard	89441A	Vector Signal Analyzer
Hewlett Packard	89431A	RF Section (VSA)
Hewlett Packard	E4401B	Spectrum Analyzer
Hewlett Packard	8753E	Network Analyzer
Hewlett Packard	436A	Power Meter
Hewlett Packard	8481B	Power Sensor

Receive Site(s)

Manufacturer	Model	Product
Panasonic	TU DST50W	8-VSB STB
Pioneer	SH-D500	8-VSB STB
Nokia	Media Master 9600	COFDM STB
NDS	System 3000	COFDM Professional RCVR
Sony	PVM 13420	Color Video Monitor (dual)
Winegard	AP8780	Preamplifier
Kay	839	Step Attenuator
Comark	CI 7802	3 dB Splitter

APPENDIX D